

**VIDEO RECORDING SYSTEM UTILIZING EXTERNAL VIDEO STORAGE  
TO RECORD STREAMING VIDEO DATA VIA AN ISOCHRONOUS  
INTERFACE**

Background of the Invention

Field of the Invention

The present invention relates to information storage and display systems utilizing rotating storage drives, and more particularly, to video recording systems that record streaming video data.

Description of the Related Art

Video recording systems, such as personal video recorders, typically utilize hard disk drive technology to store and replay video images. Such hard disk drive technology has traditionally been used in computer-related applications. By coupling the large, yet finite, storage capability (*e.g.*, 15 GB or more) and non-volatile memory of an internal hard disk drive, and video compression and decompression capabilities, personal video recorders allow users to pause and resume live television or to observe instant-replay while continuing to record the same incoming video data stream. These capabilities are not provided by video cassette recorders that utilize magnetic tape storage, which is a sequential access medium (*i.e.*, to jump from a particular stored video data stream to another, the tape must be advanced or rewound).

The storage space available for storing streaming video data in a personal video recorder is limited to the storage capacity of the internal hard disk drive within the personal video recorder itself. As such, once the storage capacity of the internal hard drive is completely filled with data, further video data storage requires rewriting over previously stored video data. Users can then only store an incoming video data stream at the cost of removing a previously stored video data stream.

There is, therefore, a need to provide the capabilities of video recording systems, while also providing the flexibility of adding storage capacity for video data streams.

Summary of the Invention

The present invention may be regarded as a video recording system to record an external video data stream for a video program segment selected using an electronic program guide. The video recording system comprises a user interface that receives user input, a video input interface that receives the external video data stream for the selected video program segment, an isochronous interface connectable to an external rotating storage drive, and a video data management system. The video data management system uses the electronic program guide to select the video program segment in response to the user input. The video data management system recognizes connection of the external rotating storage drive to the video recording system and subsequently identifies the external rotating storage drive as available for video data storage. The video data management system uses the external video data stream for the video program segment to provide streaming video data, and routes at least a portion of the streaming video data to the external rotating storage drive via the isochronous interface in order to record the external video data stream for the video program segment.

The present invention may also be regarded as a method of enabling the recording of an external video data stream for a video program segment selected using an electronic program guide. The method receives user input by a video recording system that comprises an isochronous interface connectable to an external rotating storage drive. The method receives the external video data stream for the selected video program segment by the video recording system, and uses the electronic program guide to select the video program segment in response to the user input. The method recognizes connection of the external rotating storage drive and subsequently identifies the external rotating storage drive as available for video data storage, and uses the external video data stream for the video program segment to provide streaming video data. The method routes at least a portion of the streaming video data to the external rotating storage drive via the isochronous interface in order to record the external video data stream for the video program segment.

Brief Description of the Drawings

Figure 1 schematically illustrates a video recording system in accordance with an embodiment of the present invention that includes a video data management system that uses an external video data stream for a video program segment to provide streaming video data, and that routes at least a portion of the streaming video data to an external rotating storage drive via an isochronous interface in order to record the external video data stream for the video program segment.

Figure 2 schematically illustrates an exemplary embodiment of the present invention wherein the video recording system further comprises a set-top box that receives the external video data stream from a multiple-service operator.

Figure 3 schematically illustrates another exemplary embodiment of the present invention wherein the video recording system further comprises a personal video recorder with an internal hard disk drive, and which is coupled to multiple external hard disk drives.

Figure 4 is a flow diagram in accordance with an embodiment of the present invention that uses an external video data stream for a video program segment to provide streaming video data, and routes at least a portion of the streaming video data to an external rotating storage drive via an isochronous interface in order to record the external video data stream for the video program segment.

Detailed Description of the Preferred Embodiment

Figure 1 schematically illustrates a video recording system 10 in accordance with an embodiment of the present invention. The video recording system 10 comprises a user interface 20 that receives user input 22, a video input interface 30 that receives an external video data stream 32 for a selected video program segment 34, an isochronous interface 40 connectable to an external rotating storage drive 42, and a video data management system 50. Preferably, the isochronous interface 40 is compatible with asynchronous communication, as well as with isochronous communication. The video data management system 50 uses an electronic program guide 52 to select the video program segment 34 in response to the user input 22, recognizes connection of the external rotating storage drive 42 to the video recording system 10 and subsequently

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1 systems and satellite systems. Alternatively, the external video data stream 32 can be  
2 received from UHF or VHF broadcast signals using an antenna.

3 The video input interface 30 is configured to ensure that the external video data  
4 stream 32 received by the video input interface 30 has a format which is compatible  
5 with by the video data management system 50. For example, to provide compatibility  
6 of the video recording system 10 with an analog-formatted external video data stream  
7 32, the video input interface 30 of one embodiment comprises an MPEG (Motion  
8 Pictures Experts Group) encoder, which generates a compressed digitally-formatted data  
9 stream in response to the analog-formatted external video data stream 32, and  
10 communicates the compressed digitally-formatted data stream to the video data  
11 management system 50. In addition, less storage capacity is required to record the  
12 compressed digitally-formatted data stream than the analog-formatted external video  
13 data stream 32. Furthermore, for particular embodiments that are compatible with an  
14 encrypted external video data stream 32 (*e.g.*, video data streams from premium cable  
15 channels), the video input interface 30 comprises a decrypter. Alternatively, in other  
16 embodiments of the present invention, the encoding and decrypting features described  
17 above may instead be performed by the video data management system 50, or by some  
18 other device upstream of the video recording system 10. Persons skilled in the art are  
19 able to provide a video input interface 30 that receives and appropriately responds to the  
20 external video data stream 32 in a manner in accordance with the present invention.

21 In one embodiment of the present invention, the isochronous interface 40 is  
22 coupled to the video data management system 50 in order to receive the streaming video  
23 data 54 corresponding to the external video data stream 32 for the video program  
24 segment 34 to be recorded. In addition, the isochronous interface 40 communicates  
25 various video data management commands from the video data management system 50  
26 to the external rotating storage drive 42. In certain embodiments of the present  
27 invention, the isochronous interface 40 is compatible with the IEEE 1394 standard,  
28 which is described in the "IEEE Std 1394-1995 IEEE Standard for a High Performance  
29 Serial Bus," August 30, 1996, which is incorporated by reference herein.

In particular embodiments of the present invention, the isochronous interface 40 includes capabilities to encrypt the streaming video data 54 before it is recorded onto an external rotating storage drive 42 to provide protection from unauthorized copying or transporting of stored video data by exchanging external rotating storage drives 42 between different video recording systems 10. Alternatively, in other embodiments, the isochronous interface 40 is capable of applying DTLA ("Digital Transmission Licensing Administrator") copy protection utilizing authentication key exchange to the video data routed to the external rotating storage drive 42. DTLA copy protection is a well-known copy protection system, compatible with the IEEE 1394 standard, and is described in "Digital Transmission Content Protection Specification Revision 1.0," March 17, 1999, which is incorporated by reference herein. By applying DTLA copy protection to the video data routed to the external rotating storage drive 42, the routed video data is protected from unauthorized copying.

The preferred embodiment of the present invention is connectable via the isochronous interface 40 to an external rotating storage drive 42 that is an external hard disk drive compatible with the IEEE 1394 standard. Alternatively, the external rotating storage drive 42 can be a writable digital video disk (DVD) drive, or another technology that provides writable non-volatile storage.

In embodiments which utilize an isochronous interface 40 and external rotating storage drives 42 that are compatible with the IEEE 1394 standard, up to 1023 bus segments may be connected together, with up to 63 external rotating storage drives 42 daisy-chained to each bus segment. Additionally, a full storage drive 42 can be disconnected and replaced with an empty storage drive 42. Thus, video recording systems compatible with the IEEE 1394 standard provide nearly unlimited storage capacity.

In the embodiment illustrated in Figure 1, the electronic program guide 52 is a database containing information regarding the broadcast schedules for various video program segments from various broadcast channels. This information is typically expressed in the form of a program grid with columns denoting the time periods, and with separate rows for each of the available broadcast channels. In one embodiment,

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skilled in the art are able to provide an appropriate configuration and communication scheme between the video data management system 50 and the external rotating storage drives 42 compatible with the present invention.

In the embodiment illustrated in Figure 1, the video data management system 50 uses the external video data stream 32 for the video program segment 34 to provide streaming video data 54. Where the external video data stream 32 for the video program segment 34 is already in a format compatible with storage on an external rotating storage drive 42 via the isochronous interface 40, the video data management system provides streaming video data 54 which is unchanged from the external video data stream 32. Alternatively, where the external video data stream 32 is not in a compatible format, the video data management system 50 provides streaming video data 54 which comprises some conversion (*e.g.*, encoding or encryption). In alternative embodiments, this conversion may be performed by the isochronous interface 40.

In the embodiment illustrated in Figure 1, the video data management system 50 routes at least a portion of the streaming video data 54 to the external rotating storage drive 42 via the isochronous interface 40 in order to record the external video data stream 32 for the video program segment 34. In embodiments in which the video recording system 10 comprises an internal rotating storage drive, such as a hard disk drive, the video data management system 50 selectively routes portions of the streaming video data 54 among the internal rotating storage drive and the connected external rotating storage drives 42, depending on the storage availability of the various drives.

Figure 2 schematically illustrates an exemplary embodiment of the present invention wherein the video recording system 10 further comprises a set-top box 100 that receives an external video data stream 32 from a multiple-service operator (MSO). A set-top box is a known device typically used to receive user input 22 via a user interface 20, to receive an external video data stream 32 from an MSO via a video input interface 30, and to provide an output video data stream in response to the external video data stream 32. The output video data stream of a known set-top box is typically configured to be compatible with other video devices which may be coupled to the set-top box, such as video cassette recorders and televisions. Providing a set-top box 100,



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The video input interface 30 of the embodiment illustrated in Figure 3 is coupled to a set-top box and receives the external video data stream 32 for the selected video program segment 34 and is coupled to the video data management system 50 via the encoder 210. The encoder 210 compresses (*i.e.*, encodes) the video data stream from the video input interface 30 using the MPEG-2 compression technique, which is a known video data compression standard. The compressed video data stream is then communicated to the stream controller 220 as streaming video data 54 in the format of an MPEG single program transport stream. In an alternative embodiment of the present invention, the encoder 210 is compatible with other compression techniques, including, but not limited to, wavelet compression, motion JPEG compression, and DV25 compression. In the embodiment illustrated in Figure 3, the encoder 210 also utilizes a SDRAM memory 212.

In addition, in the embodiment illustrated in Figure 3, the electronic program guide 52 is received from the set-top box via the isochronous interface 40, and is communicated to the microprocessor 230 and the on-screen graphics driver 250. The microprocessor 230 uses the electronic program guide 52 to select the video program segment 34 in response to the user input 22.

The isochronous interface 40 of the embodiment illustrated in Figure 3 is compatible with the IEEE 1394 standard and is coupled to the video data management system 50 via the stream controller 220. In addition, as illustrated in Figure 3, the isochronous interface 40 is connectable to multiple IEEE 1394-compatible external hard disk drives 42. The microprocessor 230 recognizes connection of the external hard disk drives 42 and subsequently identifies the external hard disk drives 42 as available for video data storage.

The video output interface 60 of the embodiment illustrated in Figure 3 is coupled to the video data management system 50 via the decoder 240 and the on-screen graphics driver 250. The decoder 240 performs the inverse function of the encoder 240. By generating a video data stream that is compatible with display on the television 62, the decoder 240 enables the display of stored video data streams from the various

1 storage drives coupled to the personal video recorder 200. In the embodiment  
2 illustrated in Figure 3, the decoder 240 also utilizes a SDRAM memory 242.

3 The on-screen graphics driver 250 generates a graphical representation of the  
4 electronic program guide 52 and other control parameters of the personal video recorder  
5 200, which is displayed on a television 62 via the video output interface 60.  
6 Responding to the displayed graphical representation, the user may indicate to the  
7 personal video recorder 200 which video program segments 34 are selected for  
8 recording from the external video data stream 32, as well as to control various other  
9 operation parameters of the personal video recorder 200.

10 The internal hard disk drive 70 of the embodiment illustrated in Figure 3 is  
11 coupled to the video data management system 50 via the stream controller 220. The  
12 internal hard disk drive 70 in Figure 3 comprises an IDE ("integrated drive electronics")  
13 interface, which is a known interface for mass storage devices in which the controller is  
14 integrated into the storage drive. Because IDE-compatible hard disk drives and IEEE  
15 1394-compatible hard disk drives are not connectable to the same bus, the internal IDE  
16 hard disk drive 70 and the multiple IEEE 1394-compatible external hard disk drives 42  
17 are coupled to the video data management system 50 via separate buses.

18 Pursuant to commands from the microprocessor 230 of the embodiment  
19 illustrated in Figure 3, the stream controller 220 routes at least a portion of the  
20 streaming video data 54 to the external rotating storage drives 42 via the isochronous  
21 interface 40 in order to record the external video data stream 32 for the video program  
22 segment 34. Also, the stream controller 220 routes at least a portion of the streaming  
23 video data 54 to the internal hard disk drive 70.

24 Figure 4 is a flow diagram in accordance with an embodiment of the present  
25 invention that uses an external video data stream 32 for a video program segment 34 to  
26 provide streaming video data 54, and routes at least a portion of the streaming video  
27 data 54 to an external rotating storage drive 42 via an isochronous interface 40 in order  
28 to record the external video data stream 32 for the video program segment 34. The flow  
29 diagram is described with reference to the video recording system 10 illustrated in  
30 Figure 1. Persons skilled in the art are able to recognize that, while the flow diagram

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